Delivering Low Carbon Cooling

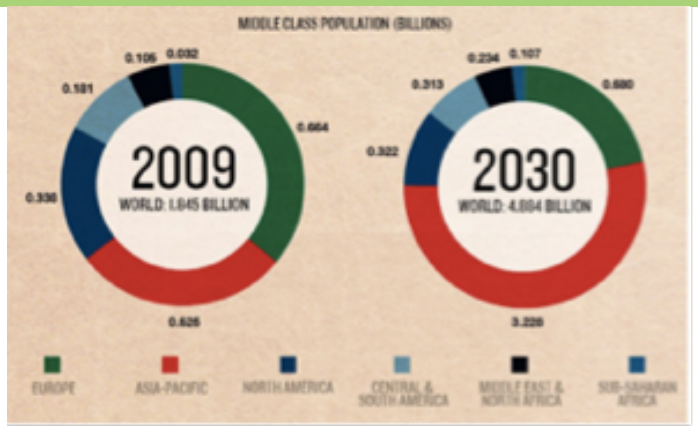
Toby Peters

Professor in Cold Economy, University of Birmingham

Why Cooling Matters?

ieadsm
energy efficiency

Emerging Markets – two extremes



ieadsm
energy efficiency

Sustainable Development Goals

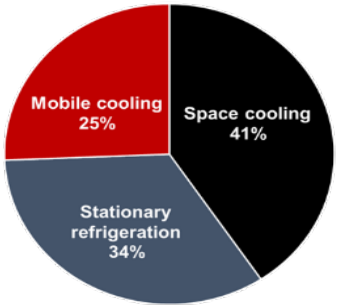
Cold sits at the nexus of the SDGs

ieadsm
energy efficiency

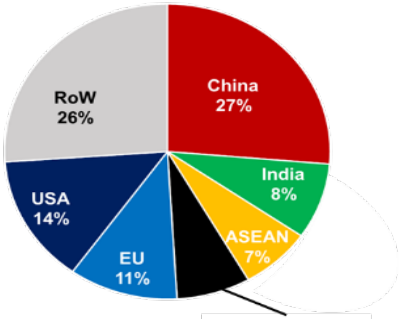
Cooling is not just air-conditioning

Global cooling energy consumption in 2018

By sector

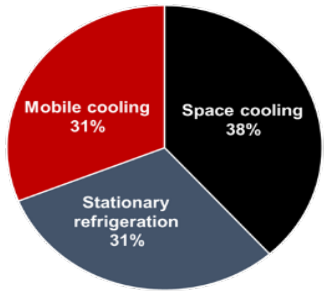


By region

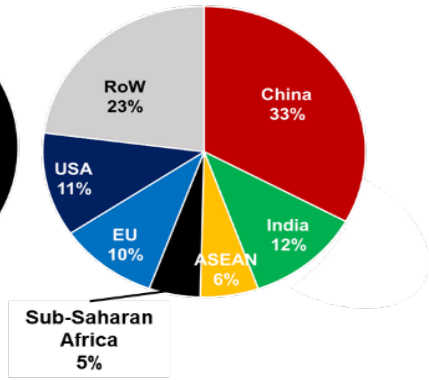


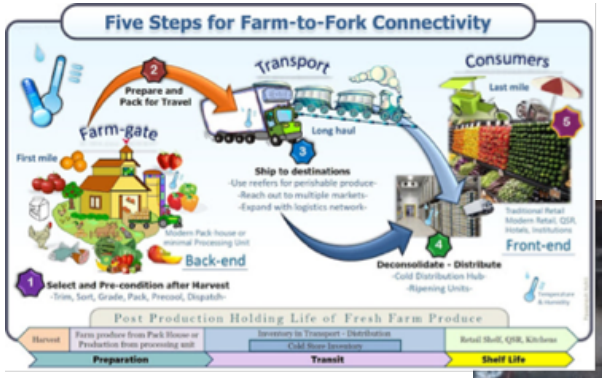
Global cooling sector CO2e emissions in 2018

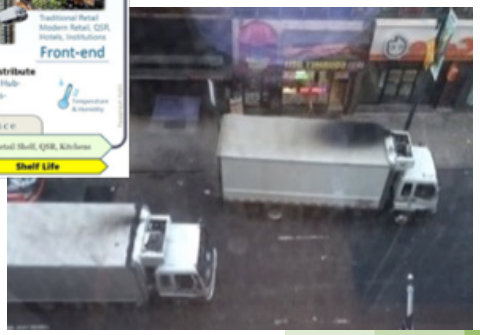
By sector



By region

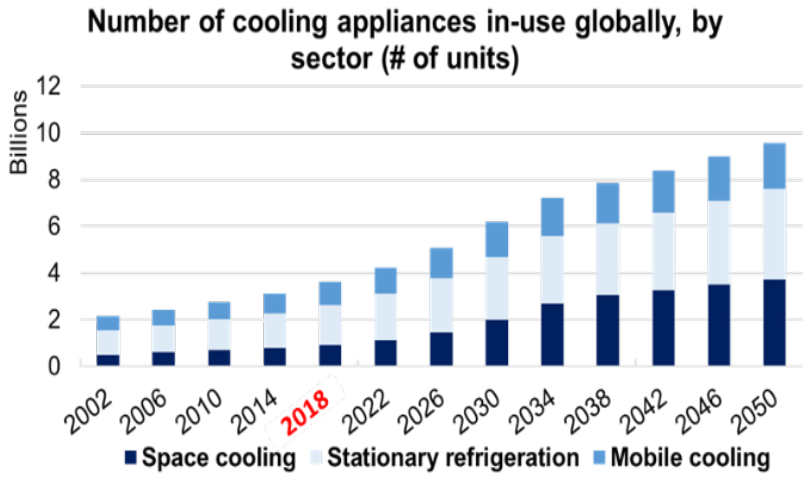


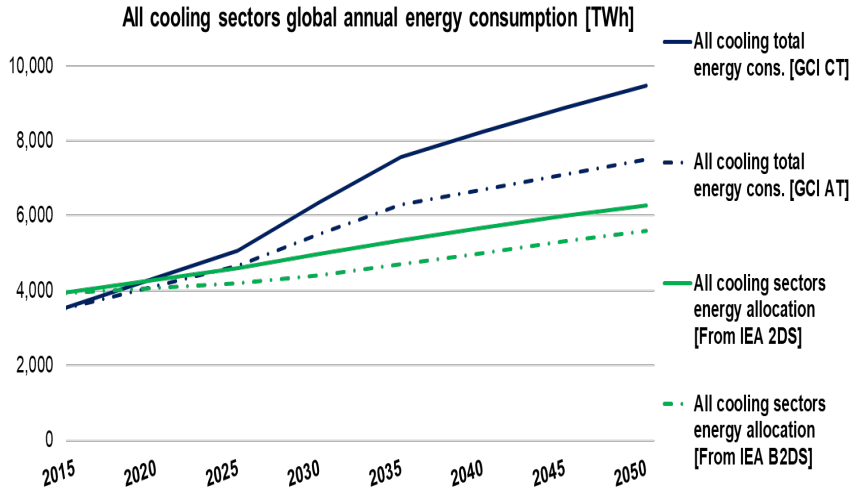




ieadsm energy efficiency

19 cooling appliances installed every second for next 30 years

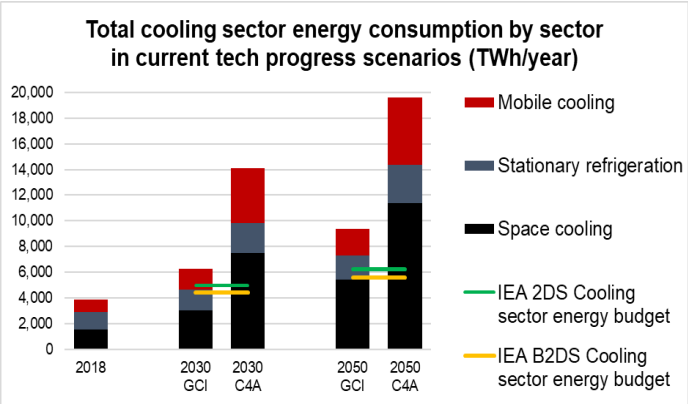


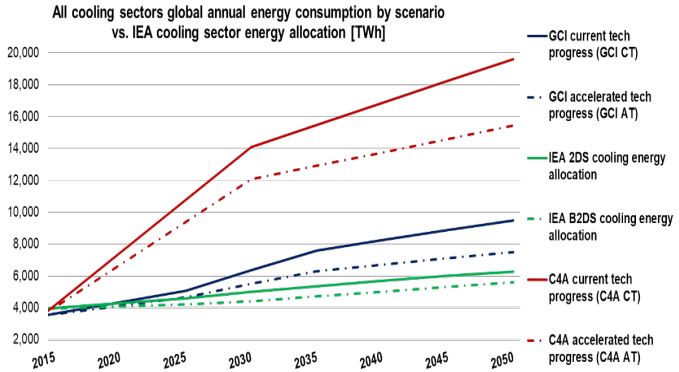


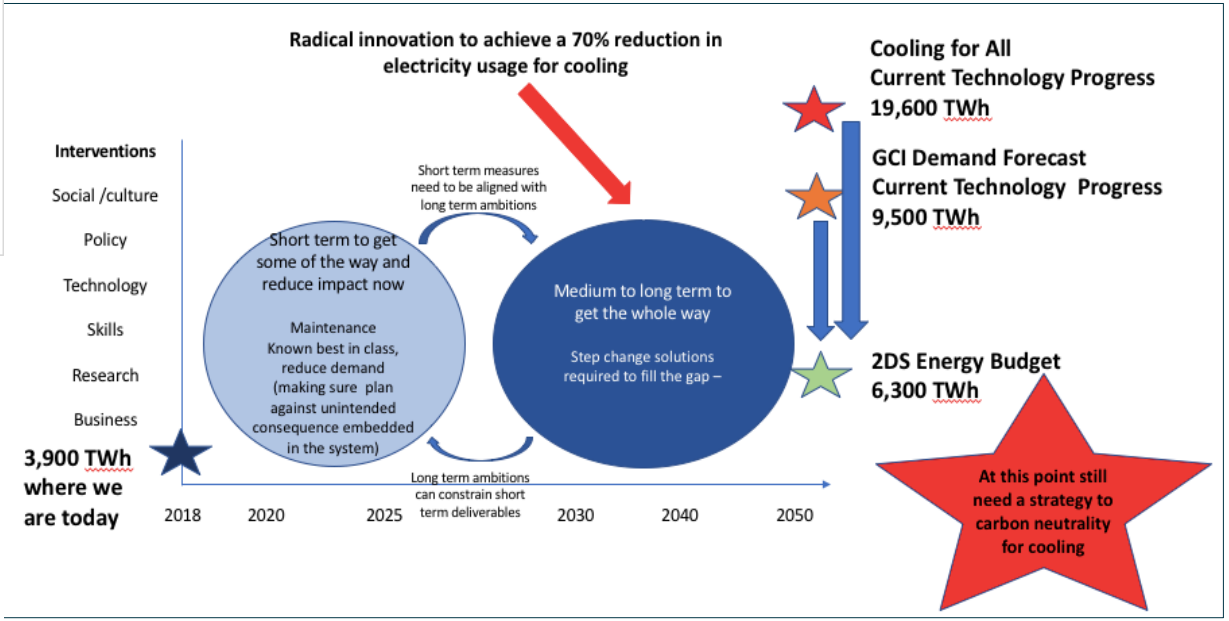
ieadsm energy efficiency

data collated from GCI, Giz Prtoklima and IEA

The Energy Conundrum of Cooling for All







ieadsm
energy efficiency

Thinking thermally

The question is *'what is the service we require and how can we provide it in the least damaging way'*, rather than *'how much electricity do I need to generate?'*

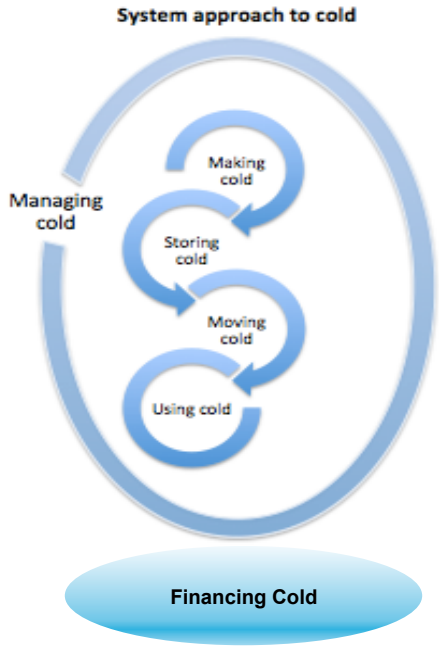
ieadsm
energy efficiency

System approach to cooling

Making cold
Harness waste/unused resources e.g.: 'wrong time' renewable energy (e.g. wind), waste cold (e.g. LNG) ambient heat & cold (e.g. ground source)

Storing cold
Thermal energy storage to warehouse

Moving cold
New energy vectors and material to shift cold



Using cold
Reduce cold loads
Increase efficiency and reduce GWP of conventional technologies
New technologies to harness new stores and vectors

Managing cold
Monitoring, controls and management

Financing Cold
How do we charge and pay for cold

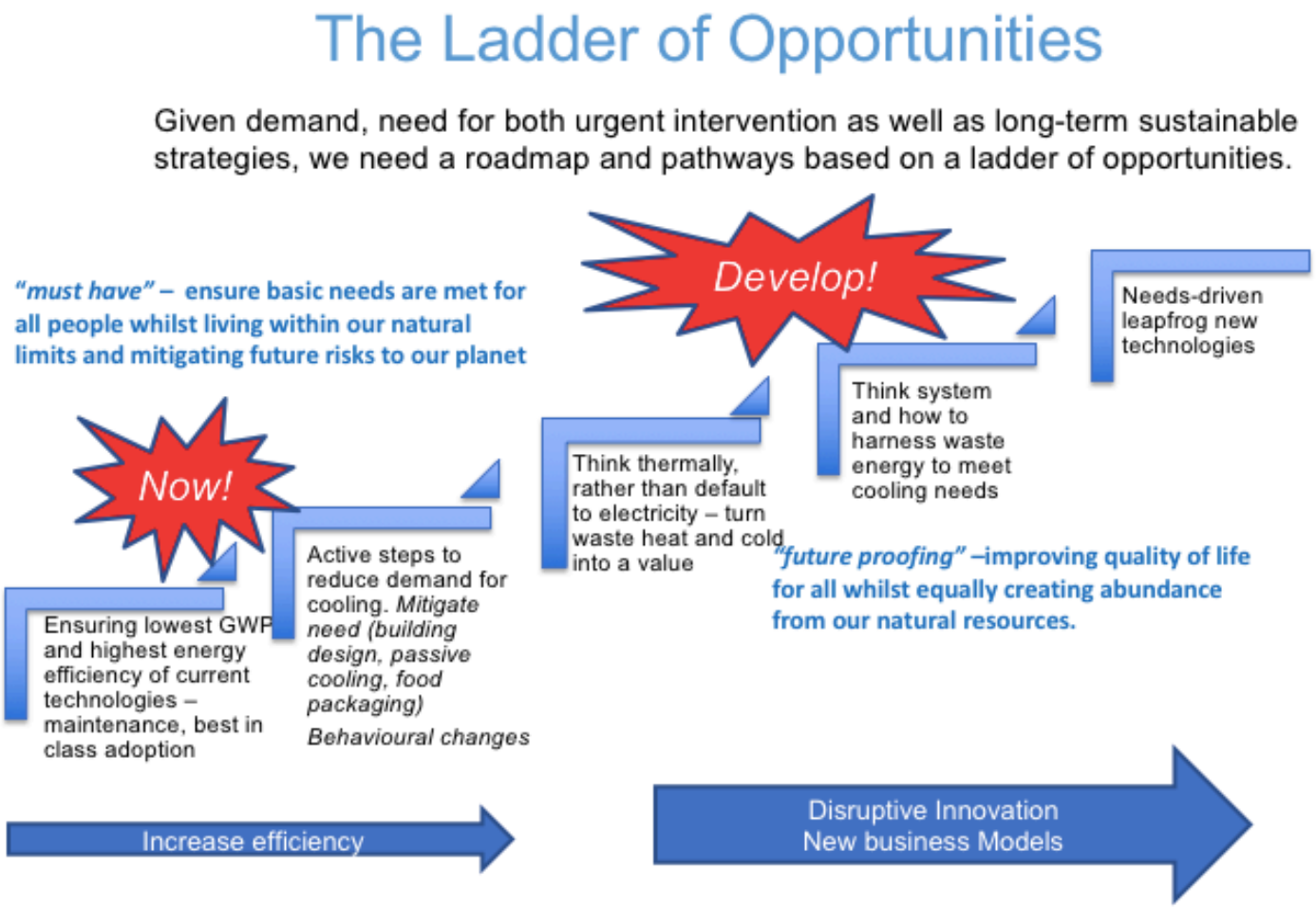
There are opportunities to access thermal resources to meet cooling needs sustainably.

Cold Resources – Numerous resources exist for example:
- Waste cold of Liquefied natural gas (LNG)
- Deep Lake or sea water
- Sky cooling

Low grade heat resources
- Process waste heat
- Geothermal
- Solar

ieadsm energy efficiency

Ladder of Opportunities



ieadsm
energy efficiency

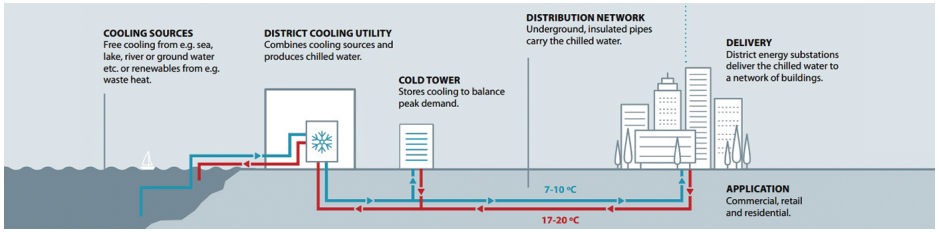
Smart Thermal Systems - What do we need to do?

Solving the cooling challenge requires a comprehensive systems approach recognising multiple interdependencies requires bundles of technologies and integrated measures and policies. These need to be fit for market and fit for finance

1. Think how cooling demand fits into the wider electrical and energy system + opportunities to use it for demand side flexibility – energy system thinking

2. Think how cooling fits into attempts to decarbonise transport – clean transport

3. Think how waste or surplus renewable resources can be accessed via process integration or storage?



becomes

District Cooling for communities

Energy Sources → Air Conditioner

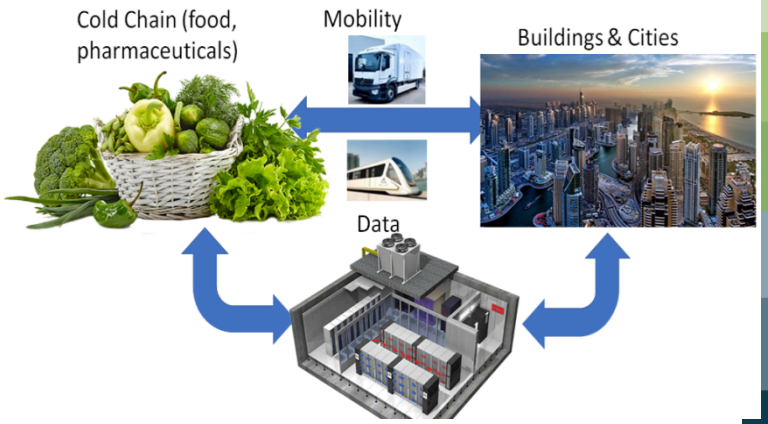
Our Proposal

Energy Sources

Liquefied Natural Gas
Harvesting cold etc
Geothermal

Smart Thermal Grid
Multiple Temperatures Level

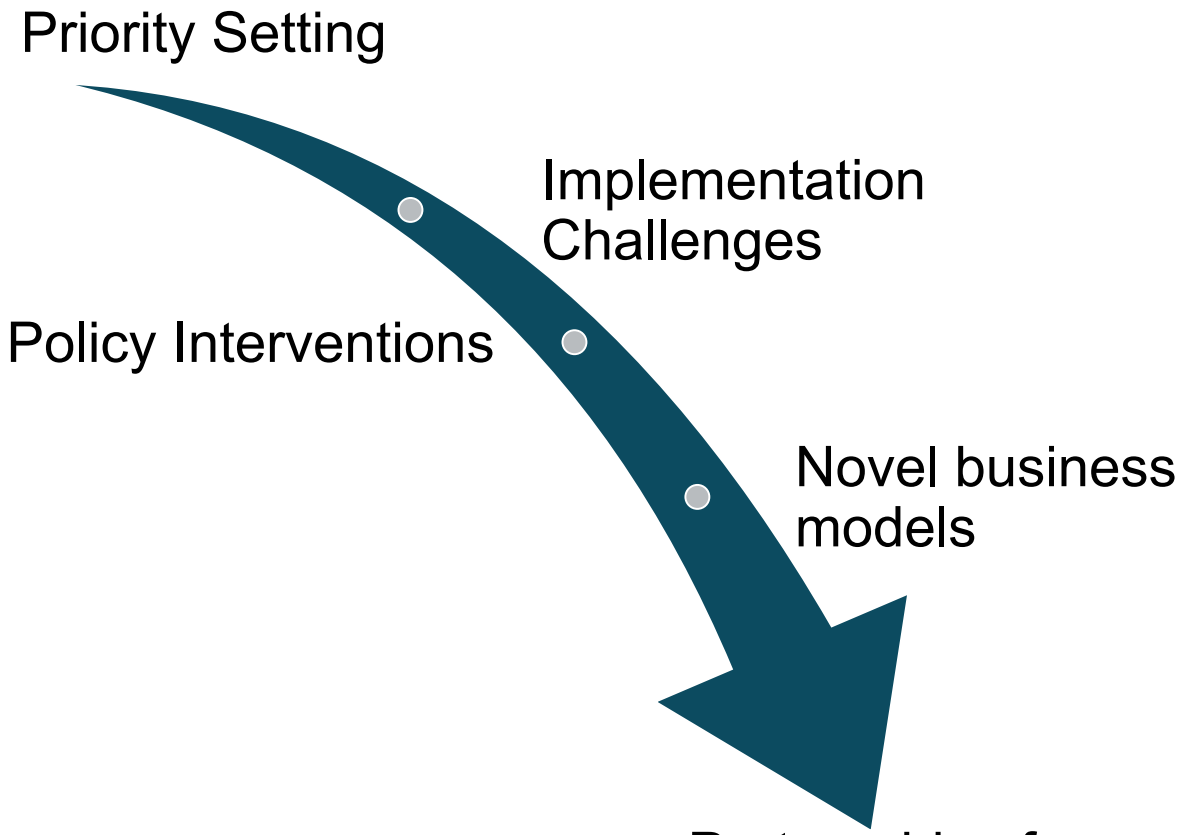
Trading Platform -Agent-based modeling, block chains, statistical aggregation/ mapping
Technologies – Cold Energy Storage and vectors (e.g. ground, gravel storage of cold, liquid nitrogen, water, new ones to be developed)



ieadsm energy efficiency

Demand-side management and behavioural change

Cooling spans many sectors. Solutions will be complex, integrated across sectors; and need to be “fit for market”



ieadsm
energy efficiency

Barriers

Issue	Description
Lack of Awareness	Cooling is a blind-spot in the key energy and climate change mitigation debates as an example only 83 of 197 Nationally Determined Contributions (NDCs) even mention refrigeration and cooling (RAC), Jordan, Ghana and Vietnam are the only countries with any explicit commitments – but it has a material role in addressing socioeconomic challenges and significant impact on the energy system, climate change and pollution.
Lack of research funding	Funding for cooling research in the EU is less than 0.22% of the total engineering research budget; OEMs spend a significantly smaller % of revenue on radical innovation than in other comparable sectors.
Investment	The high impact and patient capital investment sectors are failing to scale at the rate required to solve pressing environmental and social challenges, including addressing the need for clean Cooling for All. UNEP has highlighted the need for new actors, coalitions and instruments to be part of the solution and help close the financing gap.
Access to Finance	Some types of cooling equipment are too expensive for the people who would benefit from them to purchase. This seems to be especially true of pre-cooling systems that could be used to reduce food spoilage in the agricultural sector, though also relevant to domestic refrigeration and space cooling.
Electricity Availability	The vast majority of today's available cooling technologies are reliant on electricity access. Currently about 87% of the world has access to electricity. In sub-Saharan Africa this figure falls below 43% of the population. Lack of electricity supply prevents universal access to cooling in many developing and emerging economies. In countries that do have access to electricity the robustness of the power grid and security of supply can be an issue too, as for example in India where blackouts are common both in the urban and rural environments.
Skills	The skills challenge is two-fold. Firstly, using refrigeration, and by installation, maintenance and servicing of refrigeration and space economies and deployment of equipment at scale creates a subst
Lack of Policy Incentives	In many (developing) countries mitigation related investments in remains largely untapped. This indicates that there is a general lack of conducive policies to drive low carbon transition in the RAC sector. Globally, numerous government incentive schemes are in existen of refrigeration technology to help reduce post-harvest losses are housing initiatives or building codes.
Split incentives	i.e in the building sector, those responsible for paying energy bills

Issue	Description
National Interest vs. MEPS	Minimum efficiency performance standards (MEPS) and similar initiatives can be a very effective mechanism for enhancing the efficiency of equipment sold in a market place. However, attempts to protect national producers can lead to varying efficiency standards between markets. MEPS also tend to focus on performance of traditional VPC units, rather than deployment of more radical innovations and system-based solutions for cooling
Higher Purchase Prices for more efficient equipment vs. total cost of ownership savings	Frequently, more efficient technology comes with a price premium. Often customers in both domestic and commercial markets tend to be more sensitive to purchase prices as opposed to total cost of ownership. Few customers consider the in-life energy usage of their cooling appliances completely and because high quality consumption data is frequently lacking, comparisons between offerings are difficult for them to make. In many markets energy is so cheap or subsidised that conserving it is not incentivised.
Pipeline	Deploying the 'best in class' technologies available today is unlikely to be enough to avoid energy consumption and emissions that substantially exceed the sector's allocation in 2DS. OEMs also operate to short strategic timescales, for example 2020 as a focus with 2030 being the absolute limit of planning.
Proving Integrated Systems	A desire by many companies and organisations to get more out of their technology portfolio is forcing the combination of existing technologies in novel ways in a drive for an optimal overall system. Whilst in principal this approach could have significant benefits, currently outside of district cooling networks used for space cooling in dense urban environments and a small number of Asian LNG cold recovery projects, there are few working examples of integrated cooling systems. There appear to be no examples that attempt to leverage a wide range of technologies at district scale. As a result, the benefits remain unproven and tools that could be used to design these systems unvalidated by experience.
Culture vs. Refrigeration	In some cultures there is a perception that refrigerating food somehow compromises its freshness. Carrier UTC encountered this when exploring rural Indian agricultural markets.
Lack of Market incentives	OEMs and Tier 1s do not feel as if their customers are demanding "step-change" solutions and so are offering only incremental improvements between product releases. The general consensus among OEMs and Tier 1s is that traditional vapour compression cycles, paired with energy storage and niche usage of sorption technologies, will meet future cooling demands.
Industry	There are limited (<5) major companies in many of the segments; the incumbents are enormous and global which means that any new innovation can only access the market through them. The vapour compression cycle technology dominates all sectors with long established manufacture, supply and servicing chains with no incentive or demand to invest in change. (internal combustion engine vs EV or bagged vacuum cleaners vs Dyson).
Data	Lack of data collection (real-time) to connect fork to farm and have demand-led harvesting and supply chains

ieadsm energy efficiency

Novel business models … Cooling as a service

	Equipment	Usage Management	Monitoring and Maintenance	Energy
Equipment sale	Buy or lease	In-house	Contract	3rd party or own generation
Existing service based approach bringing maintenance and management into a single contract	Single "lease" based contract Can have a success-related payment structure linked to efficiency			3rd party or own generation
District Cooling model.	Single contract possibly with two elements to the bill based on RT (Refrigeration Tonnage) – 1. **Demand charges** are associated with the system costs for infrastructure, operations, and maintenance and based on the amount of cooling your property requires. 2. **Usage charges** are the energy costs to produce refrigeration (i.e the chilled water in the case of District Cooling). This is metered. This could be charged as either a variable against demand or as a flat rate plus an excess fee.			
Cooling as a Service	Single contract <u>based on service provided by cooling</u> i,e. per ton of food produce stored or moved (Coldhub model extended) or size of flat and hours of cooling – "I want temperature to be maintained between at 22-24'C" whilst I am home / from 6pm to 10pm –			

*CaaS in this form could unlock integrated maintenance benefits of enhanced leases, scale benefits of district cooling **<u>and</u>** delivery system optimisation opportunities e.g. intelligent building design or insulation practices through servitization*

ieadsm energy efficiency

Doing cold smarter

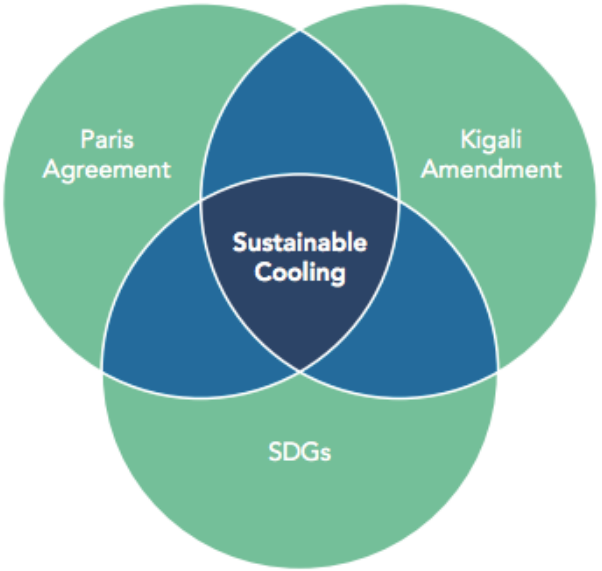
Global access to sustainable, affordable and resilient cooling to

- underpin health
- habitable, safe housing and work places
- reduce post-harvest food loss - protect food volume and quality; ensure efficient movement from farm to consumption centre
- Enhance economic wealth and security for farmers
- Achieve nutritional security and deliver safe food to the wider population
- plus, plus, plus ….

and

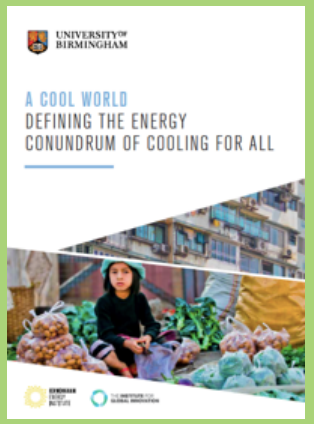
ensure that the massive growth in demand for cooling is managed within the constraints of natural resources, local economies and underpins*, rather than undermines*

✓ CO2, Climate Change and pollution targets
✓ energy efficiency and resilience
✓ sustainable and affordable infrastructure



ieadsm energy efficiency

Doing cold Smarter



Professor Toby Peters
Fellow of the Institute for Global Innovation
t.peters@bham.ac.uk

ieadsm
energy efficiency